SUBSTITUTE SPECIFICATION (CLEAN COPY)

TITLE OF THE INVENTION

SEMICONDUCTOR INTEGRATED CIRCUIT DEVICE AND SEMICONDUCTOR INTEGRATED CIRCUIT CHIP THEREOF

BACKGROUND OF THE INVENTION

The present invention relates to a semiconductor integrated circuit device which has wide use, for example, in electronic equipment and appliances, including a computer, etc., and in particular, it relates to a semiconductor integrated circuit device and a semiconductor integrated circuit chip for the device, which enables averaging or flattening of the temperature distribution inside of an element, through transfer (or diffusion) of heat generation within the integrated circuit of such device during operation thereof, thereby suppressing an increase of local temperature within the semiconductor chip of the integrated circuit device.

Conventionally, such as according to Patent Document 1 listed below, a device for diffusing (or transferring) the heat from a heat generating body, such as a semiconductor or the like, which is mounted on the electronic equipment, is provided, for example, with a heat diffusing panel or plate, wherein a loop-like groove is formed on a contacting surface of each of an upper plate and a lower plate of high heat-conductive material, in which both plates are connected by laying one on top of another, so that the said loop-like grooves are opposing to each other, thereby building up a heat pipe within an inside thereof.

Generally, as a device for transferring heat from the heat

generating body, it is also known that the heat can be transferred through driving a fluid enclosed within an inside thereof, for example. In the device disclosed in the below-listed Patent Document 2, for example, the transferring of heat from a printed circuit board, on which a plural number of semiconductor devices or elements (i.e., the heat generating bodies) are mounted, is effected through the provision of an electrical heating means, which is formed in a part of the liquid flow passage formed and is built up with a capillary. The liquid within an inside of the capillary is heated, reaching boiling temperature, which causes pulse-like abrupt action of the liquid (i.e., generating bumping), thereby driving the liquid, due to a sudden increase of pressure accompanying evaporation when generating the bumping.

However, the principle of transferring the heat with using such vibration of the liquid is described, in more detail, such as, in the below-listed Non-Patent Document 1.

Also, in the below-listed Non-Patent Document 2, particularly, in Figure 10 thereof, there is disclosed a structure for diffusing the heat generated from a semiconductor chip having a large electric power consumption by using a vessel or container to thereby achieve a device for transferring the heat through utilizing the vibration of the heat pipe and/or the liquid.

[Patent Document 1]

Japanese Patent Laying-Open No. 2002-130964 (2002)

[Patent Document 2]

Japanese Patent Laying-Open No. Hei 7-286788 (1995)

[Non-Patent Document 1]

"Enhancement of Heat Transfer by Sinusoidal Oscillation of

Fluid (Transient Behavior of a Dream Pipe)" (pp 228-235), by Mamoru OZAWA and 5 others, Vol. 56, No. 530 (1990-10), a collection of papers of Japan Machinery Institute (B-Edition)

[Non-Patent Document 2]

Z.J. Zuo, L.R. Hoover and A.L. Phillips, "An integrated thermal architecture for thermal management of high power electronics", pp 317-336, Suresh V. Garimella, Thermal Challenges in Next Generation Electronic System (PROCESSING OF INTERNATIONAL CONFERENCE THERMES 2002), FANTA FE, NEW MEXICO, USA, 13-16 JANUARY 2002

In recent years, for highly integrated semiconductor chips of the type used for calculation processing such as in the computer, etc., for example, great demands have been made not only for achieving significant improvements in the down-sizing of the chip-die thereof and also in the speed-up of calculation processing but, also, on reduction of electric power density per chip, accompanied with a demand for lower electric power consumption. In order to satisfy these demands, an improvement is made on a technology of mounting a logical element and a memory element within the same chip (commonly named "System On Chip"), for example.

In such semiconductor chip, the memory element portions, each being smaller in the electric power density compared to that of the logical element, are mounted on the same semiconductor chip with the logical elements. Because of the mixing elements with different power requirements, the electric power density per such chip is smaller compared to that of the conventional semiconductor chip. However, in a semiconductor chip of the former as a whole, a large difference exists in the locally generated electric power consumption of different portions of the chip. Further, in a portion of the logical element(s), there is also produced a distribution of the electric power density, and, as a result thereof, there is also generated a large difference in the electric power density

within the chip.

Since the difference of the electric power density appears to be the difference of the heat generation density in the semiconductor chip, a large temperature distribution is generated when operating such chip, on which are mounted both the logical elements and the memory elements. For example, there may be a local increase of temperature (so called, a "hot spot") within the logical element portion(s). And, if such hot spot reaches an upper limit of junction temperature of a transistor, it causes thermal runaway of the semiconductor element; therefore, it is necessary to provide any means or measure for dissolving such hot spot. Also, the generation of such hot spot is a great reason for reducing an operation permissible temperature (i.e., the maximum temperature permissible for the package, so as to guarantee a normal operation of the circuits of the semiconductor chip mounted within that package) of the integrated circuit package mounted on the said semiconductor chip. For this reason, an entire cooling structure thereof is sized to be large. Therefore, it is impossible to apply it into a small-size computer and/or a small-size electronic appliance and, in particular, to such a unit that is portable, such as, a "desk top" type or a "note-size" type, and also to apply it into a computer, in which the integrated circuit packages are mounted in a plural number thereof with high density, such as with regard to a "rack mount server" and/or a "blade server", etc.

Contrary to this, for example, with a heat transfer or diffusing mechanism as that shown in the Patent Document 1 and/or the Patent Document 2, mentioned above, such structure is adopted therein that the semiconductor elements (i.e., chips), which constitute the heat generating body, are attached on the heat diffusing plate through a high heat conductive grease, a high heat conductive adhesive, or a high heat conductive rubber, etc. For this reason, in the case when a hot spot is generated within said heat-generating parts, the hot spot is diffused into the heat diffusing plate through the grease, the adhesive or the rubber,

which is thermally connected to the heat generating parts, directly. By the way, the high heat conductive grease, adhesive or rubber has a thermal conductivity of an order of 10 W/(m·K), at the highest, but, even in the case of the largest one, this is still remarkably small compared to the thermal conductivity of metal or a semiconductor such as, aluminum or silicon (which is in an order of 100 W/(m·K), for example). For this reason, with such a structure, in which the semiconductor chips, being the heat generating parts, are attached onto the heat diffusing plate through the grease, the adhesive or the rubber, relating to the conventional art, there still remains a problem that a large difference of temperature occurs within the semiconductor chip due to the hot spot.

BRIEF SUMMARY OF THE INVENTION

According to the present invention, which takes into consideration the problems and/or limitations of the conventional techniques mentioned above it is an object thereof to provide a semiconductor integrated circuit device and a semiconductor integrated circuit chip for it, wherein the "hot spot" can be reduced, the "hot spot" is generated within the semiconductor chip due to the small-sizing of the chip and/or the difference in the electric power density, so as to suppress or flatten the difference in the heat distribution generated within the semiconductor chip, but without lowering the permissible temperature of the integrated circuit package mounting the semiconductor chips thereon and, as a result of this, enabling the small-sizing and light-weight of the cooling structure as a whole, with ease.

Namely, according to the present invention, for accomplishing the object mentioned above, there is provided a semiconductor integrated circuit chip, formed as a plate-like semiconductor chip, comprising: a circuit forming layer, on which a plurality of circuits are formed, being formed on one surface side of the plate-like semiconductor chip; and a heat transfer

layer, being connected with the plate-like semiconductor chip in one body, being formed on another, opposing surface side of the semiconductor chip, wherein said heat transfer layer is made of a material similar to that of said semiconductor chip, and comprises, in an inside thereof: a closed flow passage; an operating fluid hermetically enclosed within said closed flow passage; and driving means of said operating fluid.

Further, according to the present invention, in the semiconductor integrated circuit chip, as described above, both said plate-like semiconductor chip and said heat transfer layer are made of a material of silicon, or said driving means of the operating fluid is made of means for giving vibration to said operating fluid hermetically enclosed within said closed flow passage, or said vibration giving means includes a resistor layer. The resistor layer may be disposed in a region where heat generation density is lower than an average of heat generation density of said integrated circuit chip as a whole.

Also, according to the present invention, in the semiconductor integrated circuit chip, as described above, said operating fluid is water, or said plate-like semiconductor chip is a type of chip, wherein logic elements and memory elements are formed separately within the one surface side thereof, on which the circuits are formed.

Also, according to the present invention, in the semiconductor integrated circuit chip, as described above, possibly, a plurality of closed flow passages, formed in said heat transfer layer, areformed at said another surface side of said semiconductor chip, and each of the plurality of closed flow passages has a means for driving the operating fluid enclosed within an inside thereof, independently, and further comprising a plurality of temperature detecting means provided within said semiconductor chip, wherein a plurality of driving means are provided independently and are controlled in dependence on temperature detection outputs from said temperature detecting

means. Alternatively, it is also possible that the semiconductor integrated circuit chip, as described above, further comprises another closed flow passage which is formed at a same surface side of said semiconductor chip as said plurality of closed flow passages, crossing over said plurality of closed flow passages, and, further, each of said plurality of closed flow passages has a means for driving the operating fluid enclosed within an inside thereof, independently, and moreover, further comprising a plurality of temperature detecting means which are provided within said semiconductor chip, wherein plural driving means, which are provided for the plural closed flow passages, respectively, are controlled in dependence on temperature detection outputs from said temperature detecting means.

And, also, according to the present invention, for accomplishing the object mentioned above, there is provided a semiconductor integrated circuit chip, comprising: a plate-like semiconductor chip; a circuit forming layer, being formed on one surface side of said plate-like semiconductor chip, on which a plurality of circuits are formed; and a heat transfer layer, being formed on another surface side of the semiconductor chip, opposite the side on which said circuit forming layer is formed and connected therewith in one body, for suppressing a local increase of temperature caused due to heat generation of the circuit within said circuit forming layer of said semiconductor chip.

In addition to the above, according to the present invention, there is further provided a semiconductor integrated circuit device, comprising: a semiconductor integrated circuit chip, in a part of which are formed a plurality of circuits; a mounting board, in a part of which are formed wiring patterns, for mounting said integrated circuit chip thereon; a case for receiving said mounting board, on which said integrated circuit board is mounted, in an inside thereof; and a plurality of terminals, being planted outside from said case or said mounting board, and being electrically connected to the circuits formed on said semiconductor integrated

circuit chip, wherein said semiconductor integrated circuit chip is a type of semiconductor integrated circuit chip as described above.

And, according to the present invention, the semiconductor integrated circuit device, as described above, further comprises a heat sink, being attached on a part of an outer surface of said case, or the electric power to be supplied to said driving means, which is formed in said heat transfer layer of said semiconductor integrated circuit chip, is a part of the electric power to be supplied to said semiconductor integrated circuit chip through said terminals of said semiconductor integrated circuit device.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Those and other objects, features and advantages of the present invention will become more readily apparent from the following detailed description when taken in conjunction with the accompanying drawings wherein:

Fig. 1 is an enlarged cross-section view of a part of a semiconductor integrated circuit chip, according to one embodiment of the present invention, in particular for showing the details of a driving means thereof;

Fig. 2 is a view for explaining the condition of mounting the semiconductor integrated circuit device onto an appliance, which comprises the semiconductor integrated circuit chip therein, according to the one embodiment of the present invention;

Fig. 3 is a cross-section view for showing the internal structure of the semiconductor integrated circuit device, in which the semiconductor integrated circuit chips are installed, according to the embodiment of the present invention;

Fig. 4 is a perspective view for showing an outlook and the

internal structure of the semiconductor integrated circuit chip, according to the embodiment of the present invention;

Figs. 5(A) and 5(B) are a side view and an upper view of the semiconductor integrated circuit chip, according to the embodiment of the present invention, in particular, being seen from directions of arrows A and B shown in Fig. 4, mentioned above;

Fig. 6 is a view for showing another example of a passage duct formed on a flow passage (heat transfer) substrate in the semiconductor integrated circuit chip, according to the present invention; and

Fig. 7 is also a view for showing further other example of the passage duct formed on a flow passage (heat transfer) substrate in the semiconductor integrated circuit chip, according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments according to the present invention will be fully explained by referring to the attached drawings.

In Fig. 2 of the drawings is shown an outlook of the semiconductor integrated circuit device, according to the present invention (including also an exploded view of a part thereof). Namely, as is apparent from the figure, the semiconductor integrated circuit device 100 is made of a ceramic of high heat conductivity, for example, wherein a package case 105, having an external shape that is substantially cubic, and a printed circuit board (a mounting board) 103 are piled up on each other, thereby defining a closed space therebetween, and within an inside thereof is mounted a semiconductor chip 101, which is a circuit element made from a rectangular silicon plate, for example. Also, this semiconductor chip 101 is mounted on the printed circuit board (the mounting board) 103 and connected electrically therewith.

And, through the printed circuit board 103, the circuits (for example, a CPU and/or a memory, etc.) formed within the semiconductor chip 101 are electrically connected to plural external terminals, which are provided for electrical connection thereof to an outside, but not shown in the figure herein.

Also, as is shown in the figure, the semiconductor integrated circuit device 100, mentioned above, according to the present invention, is attached with a heat sink 300 for heat radiation on an upper surface thereof, for example, where the package case 105 is located, and further the semiconductor integrated circuit device is mounted at a predetermined position within a cabinet (or a housing) 400 of a server, etc. As an alternative, without being attached to such heat sink as was mentioned above, the semiconductor integrated circuit device may be installed as is within the electronic appliance, including the personal computer of the portable type, for example.

Also, the cross-section view in Fig. 3 shows the condition where the semiconductor chip 101, mentioned above, is mounted on the printed circuit board 103, on the lower surface of which are planted a plurality of pins (i.e., external terminals) 201, in the semiconductor integrated circuit device 100 according to the present invention shown in Fig. 2. However, in the figure, the same reference numerals given to those shown in Fig. 2, mentioned above, indicate the similar constituent elements thereof, and a reference numeral 104 in the figure is a high heat-conductive grease, a high heat-conductive adhesive, or a high heat-conductive rubber, which is inserted between the semiconductor chip 100 and the package case 105.

Next, Fig. 4 of the drawings shows the detailed structure of an integrated circuit board covering an area bounded by broken lines, corresponding to the semiconductor chip (i.e., a chip-die) 101, which is mounted on the semiconductor integrated circuit device 100, according to the present invention mentioned above.

Namely, in the figure, the lower surface side of the integrated circuit board 1, being the semiconductor chip 101 mentioned above, is a layer, on which a large number of circuits are formed for building up a logic element (i.e., a CPU) and/or a memory element (i.e., a memory), formed in separate regions thereof, respectively, within the same chip, by applying therein the "System On Chip" technology mentioned above, for example, through a known manufacturing method of the semiconductor device. Such layer is a so-called electronic circuit (or electronic circuit forming) layer 2.

On the other hand, on an upper surface side of the integrated circuit board 1, being the semiconductor chip 101 mentioned above (i.e., the opposite surface to the electronic circuit layer 2 on the chip-die), there is formed a closed flow passage through a plurality of passage ducts 3, being integrated in one body together with the said chip (i.e., the chip-die), and an operating fluid 4 is hermetically enclosed within an inside thereof. Also, in the vicinity of one end portion of each passage duct 3 is formed a resistor film 5 for building up a driving means of the operating fluid, while at the other end portion of each passage duct 3 is formed a buffer 6, to be a space for communicating with each other.

Fig. 5(A) shows the condition of the integrated circuit board 1, being the semiconductor chip 101, as seen from the direction of an arrow A shown in Fig. 4. However, in this figure, a reference numeral 102 represents solder balls which are inserted between the electronic circuit layer 2 of the integrated circuit board 1 and the mounted board 103. Also, Fig. 5(B) shows the condition of the integrated circuit board 1, being the semiconductor chip 101, as seen from the direction of an arrow B shown in Fig. 4.

As is apparent from these figures, on the integrated circuit board 1, being the semiconductor chip 101, the passage ducts and the buffer portions 6 are formed in a plural number thereof, in a comb-like shape, on the surface side opposing to the electronic

circuit layer 2, along with one side of the board (i.e., a horizontal side of the semiconductor chip, in the example shown in Fig. 5(B) mentioned above), and within an inside thereof is hermetically enclosed a fluid (i.e., the operating fluid 4) having a large latent heat, such as, a water or the like, for example. Also, at an end portion or on a surface in the vicinity of those passage ducts 3, opposing to the side on which the buffer portions 6, mentioned above, are formed, there are formed the resistor films 5 for building up the driving means of the operating fluid, resistor films 5 having a width equal to or a little bit larger than that of the passage duct, respectively. Namely, each of the resistor films 5 is in contact with the operating fluid 4, which is hermetically enclosed within the inside of the passage duct 3 (see Fig. 5(A)). Further, the driving means of the operating fluid, mentioned above, is, preferably, positioned in a region where the heat generating density is smaller than the average heat generating density of the chip as a whole, for the purpose of decreasing adverse influences caused by heat generation of the integrated circuit device, being the semiconductor chip 101. In the present embodiment, the driving means is formed in a region close to an end of the integrated circuit board 1. Alternatively, it may be provided at a portion of the integrated circuit board where the memory is formed, in which the heat generation is relatively small.

In Figs. 5(A) and 5(B), also, a reference numeral 7 represents temperature sensors for detecting the hot spot generated in the integrated circuit board 1, of being the semiconductor chip 101. Each temperature sensor is represented by a resistor layer formed on a lower layer of the electronic circuit layer 2. Namely, it is possible to detect the position where the hot spot is generated (in more detail, at which positions in the vertical direction of the integrated circuit board shown in Fig. 5(B)), by measuring the change of the resistance value of the temperature sensors 7. In the present embodiment, there is disclosed an example showing these temperature sensors 7 to be located at about a center of the board 1 mentioned above, while forming them alighting to the

positions where the plurality of the passage ducts 3 are formed, the temperature sensors being aligned in a direction orthogonal to the extension direction of the passage ducts 3. However, according to the present invention, it should not be restricted only to that mentioned above. For example, it is also possible to arrange the plurality of passage ducts 3 differently along a plane of the integrated circuit board 1 mentioned above (i.e., forming a different dispersion pattern on the plane), as deemed appropriate.

Next, Fig. 1 of the drawings is a partial enlarged cross-section view showing the cross-section of an end portion, expansively, on which the resistor films 5 are formed for building up the driving means of the operating fluid, in the passage ducts 3 formed in the integrated circuit board 1, of being the semiconductor chip 101. However, in this figure, unlike the structure shown in Figs. 5(A) and 5(B), there is shown an example where the resistor films 5 for building up the driving means of the operating fluid are formed on the lower side surface of the passage ducts 3 mentioned above, in the figure.

As is apparent from the figure, the integrated circuit board 1, being the semiconductor chip 101, comprises the electronic circuit (forming) layer 2, on the lower surface side of which a large number of circuits are formed, for building up the logic element (i.e., the CPU) and the memory element (i.e., the memory) within the same chip. On the other hand, on the upper side surface of the integrated circuit board 1 (i.e., the side opposing to the surface side, on which the electronic circuit layer 2 is formed) is laminated a resistor layer 12 (such as, a layer made of polysilicon, tantalum compound (TaN), etc., for example), for forming the resistor films 5, which builds up the driving means of the operating fluid, through an insulating layer 11 (such as, a layer of SiO_2, for example).

Further, on the upper surface are formed metal layers 13

on both sides of this resistor layer 12, so as to form wiring for supplying the resistor layer 12 with electric power, and further upon the upper surface thereof is formed a protection layer 14. And, further, on the upper surface thereof, a flow passage (or heat diffusing) layer (or substrate) 15 is connected with the integrated circuit board 1, integrated in one body, which is made from a silicon plate, the same material as that of the integrated circuit board 1. Further, on the lower surface of the silicon plate for building up the flow passage (or heat diffusing) substrate 15, there are formed the passage ducts 3 and the buffer 6 mentioned above, which are plural in number thereof, in advance, via a machining technology, such as, dry etching, etc., for example, and this flow passage substrate 15 is connected with the integrated circuit board 1, forming one body.

Charging of the operating fluid is carried out, by charging a liquid, such as, a water, etc., as the operating fluid 4, into an inside of the plural passage ducts 3 and/or the buffer 6, for example, when connecting the flow passage substrate 15 onto the integrated circuit board 1 in one body. Or, alternately, though not shown in the figure herein, with provision of ports for communicating between the surfaces of the passage ducts 3 and the semiconductor chip 101, the operating fluid 4 may be charged into therefrom. Upon the charging of the operating fluid 4, the charging pressure may be changed, or a gaseous portion (i.e., an air) of non-condensable gas is mixed with when charging, depending upon the characteristics of that operating fluid 4.

Also, the material for forming the flow passage substrate 15 should not be restricted only to the silicon, but may also be a material having a thermal expansion coefficient similar to that of silicon. Also, the protection layer 14, mentioned above, is provided for the purpose of protecting the resistor layer 12 from contacting with the operating fluid 4, such as water, etc., directly; however, it may be unnecessary depending upon selection of the materials of the resistor layer and the operating fluid.

As to the size of the semiconductor chip (i.e., the chip-die) that is mounted on the semiconductor circuit device 100, according to the present invention, mentioned above, it may be assumed to be ten (10) mm to several tens mm. On the other hand, the cross-section of the passage duct may have a cross-section area of ten (10) μm square to a hundred (100) μm square.

Also, though not shown in the figure herein, there is provided a means for supplying the electric power to the resistor layers 12, through the wiring made with the wiring of the metal layers 13, mentioned above, but in an intermittent or a pulse-like manner. The pulse frequency, in this instance, though depending upon the kind of operating fluid 4 used and the size of the passage ducts 3, is about from several tens Hz to several hundreds Hz. As such the pulse electric power supply means may be formed on the electronic circuit layer 2 of the integrated circuit board 1, or it may be built up with the logic element, such as the CPU, formed within the forming surface of the electronic circuit layer 2. Further, though not shown in the figure, it is also possible to utilize a portion of the electric power from a power source for supplying the driving power to the semiconductor integrated circuit device 100 according to the present invention (more specifically, a portion of the electric power may be supplied to the integrated circuit board 1 though the external terminals mentioned above), and as such the structure is advantageous from a viewpoint of simplification on circuitry thereon.

In supplement to the above, explanation will now be given in more detail about the transferring (diffusing) function of the heat generation in the integrated circuit board 1, the detailed structure of which was explained above, by referring to Fig. 1 and Figs. 5(A) and 5(B).

First, when the electric power is supplied, in the pulse-like manner, from the pulse electric power supply means mentioned above, the resistor layer 12, shown in Fig. 1, generates heat, and then

the operating fluid 4 (for example, it is water in the present example) within the passage duct 3 is heated abruptly (i.e., the pulse-like manner), and thereby being evaporated (i.e., generating the bumping) to generate bubbles of vapor 4a thereof within the operating fluid 4. Thereafter, when stopping the electric power supply of the pulse-like manner, the heat generation is also stopped by means of the resistor layer 12, and the generated operating fluid vapor 4a disappears.

Further, the protection layer 14 is necessary herein, also, for the purpose of protecting the resistor layer 12 from being damaged through the cavitations function, which is generated when the vapor 4a disappears. In this manner, supplying the pulse-like electric power to the resistor layers 12, intermittently, brings the operating fluid 4 enclosed inside to repeat the generation and expiration of the bubbles due to the vapor 4a of the operating fluid at the end portion within the inside of the passage ducts 3. And then, when the operating fluid 4 is boiled suddenly (i.e., generating the bumping), vibration is generated due to expansion of the bubbles and following an abrupt increase of pressure accompanying with the evaporation thereof. This vibration generated drives the operating fluid 4. Namely, accompanying the vibration of the operating fluid 4 within the passage ducts 3, the heat generated in the electronic circuit layer 2 of the integrated circuit board 1 (in particular, the local increase of temperature, such as, the hot spot) can be transferred (or diffused) (see the arrows shown in Figs. 5(A) and 5(B)), thereby averaging or flattening the temperature distribution within the integrated circuit board 1 and also suppressing the generation of the local increase of temperature.

In the integrated circuit board 1 mentioned above, also, the passage ducts 3 are provided in a plurality thereof and in parallel to one another, on the upper surface side of the board, and, further, each of the passage ducts 3 is constructed so that it can be driven and/or operated individually or independently.

Then, the pulse-like electric power supply means, mentioned above, detects the position of the local increase of temperature by using temperature detection signals from the temperature sensors 7, which are disposed within the board, thereby enabling to control the driving electric power to be supplied to the passage ducts 3, selectively. Namely, the pulse-like electric power is supplied (or drives), intermittently, only to the resistor layer(s) 12 of the passage duct(s) 3 corresponding to the portion(s) where the local increase of temperature, such as the hot spot, is generated in the electric circuit layer 2 of the integrated circuit board. With this, it is possible to obtain the heat transfer (or diffusion), not as a whole of the board, but only the portion where it is necessary; therefore, it is possible to achieve the heat transferring (or diffusion) function in the integrated circuit board 1, with very high efficiency.

However, in the embodiment mentioned above, the description was given only for the example where the plurality of passage ducts 3 are formed only one direction (i.e., arranged in the vertical direction shown in Fig. 5(B)) but are extended in parallel to one another, on the upper surface side of the integrated circuit board 1. However, the present invention should not be restricted only to that, and it may be also possible to form a layer of the plural passage ducts 3, which are formed in the horizontal direction in Fig. 5(B) and are in parallel to one another, further onto any one of the upper and lower layers thereof, in addition to the plurality of passage ducts being formed in the vertical direction and extended in parallel to one another. Namely, with such a structure, in particular, when dispersing the temperature sensors 7 within the plane surface of the board, it is possible to select the passage ducts 3 to be driven and/or controlled, in a sense of a plane (i.e., not only in the vertical direction, but also in the horizontal direction), with using the temperature detection signals from those temperature sensors 7, thereby achieving a heat transferring (diffusion) function of much higher efficiency.

With the embodiment mentioned above, a description was given only on the structure for selecting the passage ducts 3 to be driven by using the detection signals of the temperature sensors 7. It is also possible to select and/or control the passage duct(s) 3 to be driven but, however, without provision of such temperature sensors 7 within the integrated circuit board 1, as was mentioned above, for example, by calculating (or predicting) the heat generating portion on the basis of the control signals to the CPU (i.e., being the portion of large heat generation), which is formed within the electronic circuit layer 2 of the integrated circuit board 1. With such a structure, since such temperature sensor 7 is unnecessary, it is possible to achieve the heat transfer (or diffusion) function with high efficiency, but with a relatively simple structure thereof, therefore making this advantageous from an economical viewpoint.

According to the embodiment mentioned above, on one surface of the integrated circuit board 1, being the semiconductor chip 101 building up the semiconductor integrated circuit device 100, the electronic circuit layer 2 is formed, on which are formed the circuit elements accompanying the local increase of temperature, such as, the hot spot, representatively, while on the side, opposing to that where the electronic circuit layer 2 is formed, there are formed the layer 15 for achieving the function of transferring (or diffusing) the heat generated within the electronic circuit layer 2 (such as, the flow passage layer (or substrate), in which the passage ducts are formed in the plural number thereof, for example), as well as, the resistor layer 12 to be the heating/driving means, in one body, made of the same type of material to that of the integrated circuit board (such as the silicon, used in the present example, for example). For this reason, the heat generated within the integrated circuit board 1, being the semiconductor chip 101, can be transferred (or diffused) with high efficiency, within an inside of the board. Therefore, it is possible to suppress or eliminate the local increase of temperature, greatly, such as, the hot spot, representatively, which is caused due to the

difference in the electric power density, even in the semiconductor chip applying the "System On Chip" mentioned above therein.

Furthermore, accompanying the description in the above, with the integrated circuit package, in which such the semiconductor chip is mounted, there is no necessity to set a permissible temperature thereof to be a low value when setting it, by taking the local increase of temperature into consideration. Therefore, it can be used under the condition of relatively high permissible temperature. Namely, when installing it into an appliance, the integrated circuit package can be used under the condition of relatively high permissible temperature with ease. For example, this can be done by simply attaching such heat sink as was mentioned in the above thereto, but without accompanying with an improvement and/or high efficiency on the cooling performance for the integrated circuit package, nor large-sizing or scaling of the cooling structure thereof. Also, it is, of course, possible to be applied, in particular, into a small-sized computer and/or small-sized electronics, being necessarily portable, such as of the "desk top" and/or the "note size", for example, and, also, into computers being called the "rack mount server" and/or the "blade server", in which the integrated circuit packages in a plurality thereof with high density therein are installed.

Also, as was mentioned in the above, the flow passage layer (or the substrate) 15, in which the passage ducts 3 are formed in a plurality thereof, is made of a material (such as, the silicon, in the present example, for example) which is the same to that of the integrated circuit board 1, or is of a material close to that in the thermal expansion coefficient thereof, integrated in one body, and it is superior in the strength against stress due to the heat generated repetitively within the integrate circuit board 1. Therefore, it is possible to protect the integrate circuit board, with certainty, from an accident of leakage of the water enclosed within the passage ducts 3, which is a fatal to the electronic circuitry, and, in particular, caused by the breakage

of connection portion due to such the stress thereon. Namely, it is possible to provide a semiconductor integrated circuit device equipped with the heat transfer (or diffusion) function, which is superior in safety.

Furthermore, with the integrated circuit board 1, being the semiconductor chip 101 according to the present embodiment mentioned above, in particular, the insulating film 11, the resistor layer 12, the metal films 13 for use of wiring, and the protection layer 14 are formed, one above the other, on the surface side opposing to that on which the electronic circuit layer 2 of the board is formed, and then the flow passage layer (or the substrate) 15 is attached thereto, in which the plural passage ducts 3 are formed, in the structure thereof; i.e., it can be manufactured and achieved with ease, by applying the ordinary manufacturing technologies of the integrated circuit board, therefore it is advantageous from the economical viewpoint thereof.

Next, Figs. 6 and 7 of the accompanying drawings show other examples of the passage duct 3 formed in the flow passage (or the heat transfer) layer (or the substrate) 15, building up the integrated circuit board 1 according to the present invention. Thus, the passage duct 3 shown in Fig. 6 is one (1) piece, and is one example of forming it in zigzag manner, winding around over the entire surface of the substrate. However, as is shown in the figure, the resistor film 5 is provided at the left-hand side in an upper portion in the figure, and also the buffer 6 is formed at the position opposing to where the resistor film 5 is formed (i.e., the lower side in the shown figure 6).

Also, in Fig. 7, the passage duct 3 formed therein is only one (1) piece, as well as, winding around over the entire surface of the substrate in the zigzag manner, however both end portions thereof are connected with each other, thereby being circular-like in the shape thereof, as a whole. However, in the example of this figure, the resistor film 5 building up the driving means is provided

at a central portion on the right-hand side in the figure, while the buffer 6 is formed at a position opposing to where the resistor film 5 is formed (i.e., the left-hand side in the figure).

Thus, in these other examples regarding the passage duct 3, since the passage duct 3 is only one (1) piece, and also the resistor film 5 is only one (1) set, for building up the driving means thereof, it can be manufactured, easily. Therefore, it is suitable for providing the integrated circuit board to be relatively small in size and, also, inexpensive.

As should be fully apparent from the detailed description given above, according to the present invention, it is possible to achieve the semiconductor integrated circuit device and also the semiconductor integrated circuit chip for it, enabling the small-size and/or light-weight of the cooling structure thereof, while lowering and suppressing the differences in the thermal distribution, such as, the hot spot generated within the semiconductor chip, representatively, with certainty, accompanying the small-sizing of the chip and/or application of the System On Chip, but without reducing the permissible temperature of the integrated circuit package, in which the semiconductor chip is mounted.

The present invention may be embodied in other specific forms without departing from the spirit or essential feature or characteristics thereof. The present embodiment(s) is/are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being defined by the appended claims rather than by the forgoing description and range of equivalency of the claims are therefore to be embraced therein.